Comparison of IMPACT Model Predictions of Medical Events to Observed Medical Events from ISS and STS Missions

Human Research Program
Exploration Medical Capability Element

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"Expanding the Boundaries of Space Medicine and Technology"

Agenda

- Objectives
- Background
- Approach
- Output
- Challenges & Limitations
- Lessons Learned

Objectives

- Face validation of IMPACT model output
- Compare IMPACT output predictions of occurrence of medical events to observed occurrence of medical events from a set of ISS and STS missions (Named as ‘Real World System’ (RWS) dataset)
- Provide clinical and modeling explanation of assumptions, limitations, and outlying findings from this effort

Background

- The Integrated Medical Model (IMM) is an evidence-based decision support tool used to assess medical risk and optimize medical systems for human spaceflight missions. The IMM is baselined to the International Space Station (ISS) in terms of the spaceflight environment of low earth orbit and the ISS medical resource capability.

- Informing Mission Planning via Analysis of Complex Tradespaces (IMPACT) is the next generation evidence-based decision support tool currently under development by the Human Research Program to assess medical risk and optimize medical systems for future exploration missions to the moon and Mars. IMPACT is being designed to provide a comprehensive integrated suite of decision support tools for mission planners.

Observed Medical Data

- IMM RWS data collection – (LSAH Data Request Id 10517) – Received 4/2015
  - Encompassed thorough search of medical information related to missions, STS 114-145 and ISS 14-39/40.
  - Records were categorized based on IMM defined conditions in 2016. These observed counts were mapped to IMPACT condition where possible.
    - This created the observed counts for the comparisons
  - This serves as internal validation as these counts may have been used to model certain conditions within IMPACT.
    - To do external validation we would need to complete the same lengthy process that IMM RWS validation took, starting with requesting records for newer missions

Predicted Medical Data

- Crew and mission characteristics defined the MEDPRAT mission inputs to generate the predicted counts.
- 200,000 simulated missions generated per mission.
- Predictions for the cumulative set of missions was created by summing the individual iterations, creating 200,000 predictions

A. Mission/Crew Characteristics
Mission name
Mission length (in flight days)
Sex of each crew member
Wearing of contact lenses by each crew member
Presence of dental crowns per crew member
Number of EVAs per Crew Member

Approach

- Observed condition counts will be compared to predictions
  - Both by mission, as well as by condition.
- Condition-level determinations of accuracy
  - ***in range:*** observed counts within predicted 90% confidence interval
  - ***over-predicted:*** observed counts less than 5th percentile
  - ***under-predicted:*** observed counts higher than 95th percentile of prediction,
  - ***Indeterminate:*** Observed counts 0 and confidence interval (0,0).
    - not enough observed person-missions or person-years in rarer events to assess accuracy
    - statistically underpowered

Limitations

IMM

- Baselined to ISS missions and resources
- Medical events mapped to IMM conditions
- Classified some conditions not yet incorporated into iMED.

IMPACT

- Developed for exploration class missions and resources
- Medical events may have been captured during data collection that mapped to new IMPACT conditions, but would not have been recorded as such
- Unclassified IMM conditions could not be mapped to IMPACT.

Some Assumptions and Limitations

- **Cannot evaluate these exposures properly until we have observed data for comparison.**
  - IMPACT incidences were designed to predict medical events in multiple environments (microgravity, partial gravity, lunar surface) while shuttle and ISS are only in microgravity.

- **Observed counts may be higher for STS and ISS due to technological advancement.**
  - Many technologic advances have occurred and problems from previous missions have been corrected (new EMU, new gloves). The EL for IMPACT attempts to account for these improvements.
  - Hardware and systems differences exist between STS, ISS, and Artemis vehicles that affect crew health (CO_2 removal).
  - Some toxic and corrosive materials used in the past will not be carried in the future (ammonia).

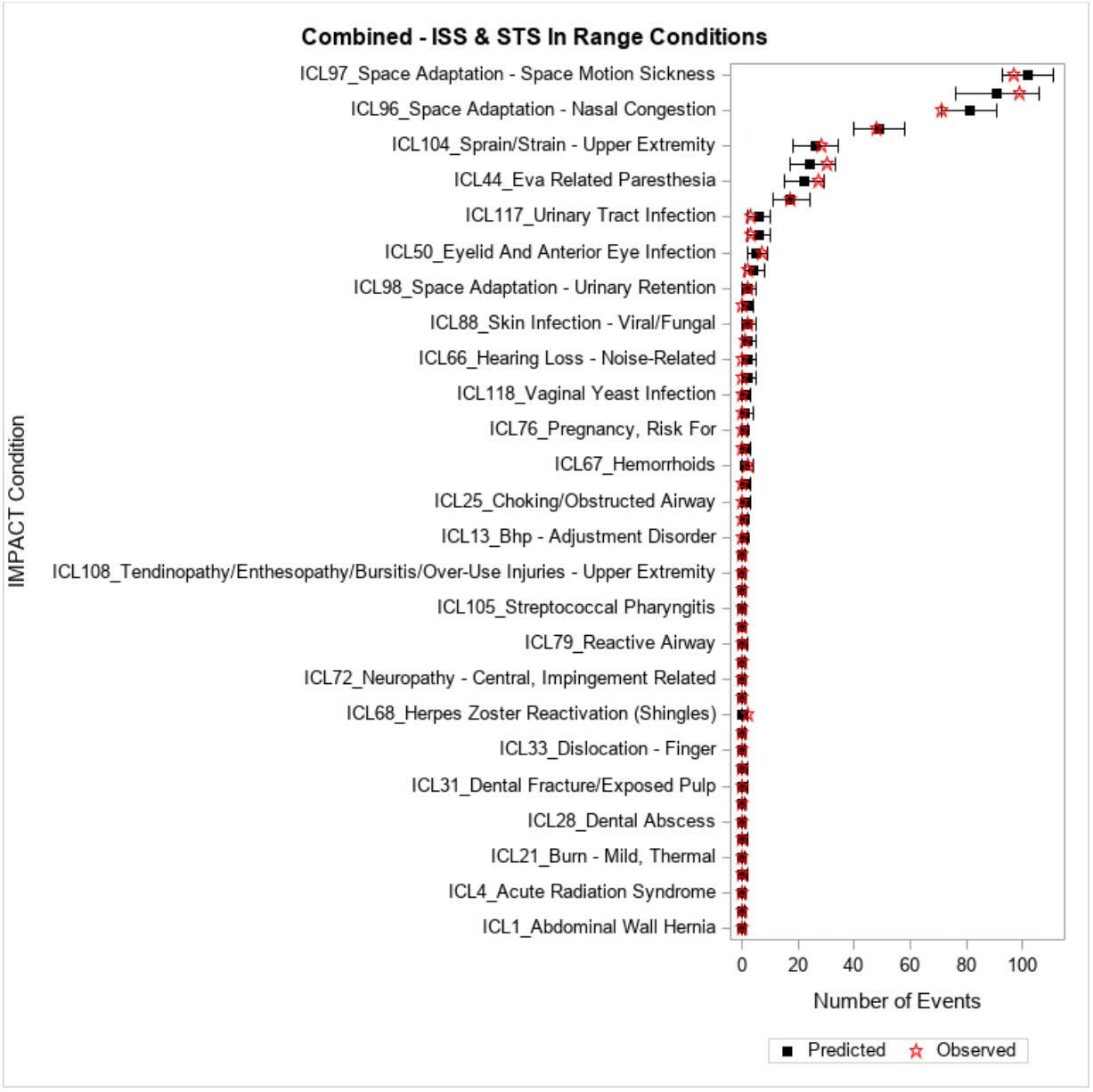
Some Assumptions and Limitations (continued)

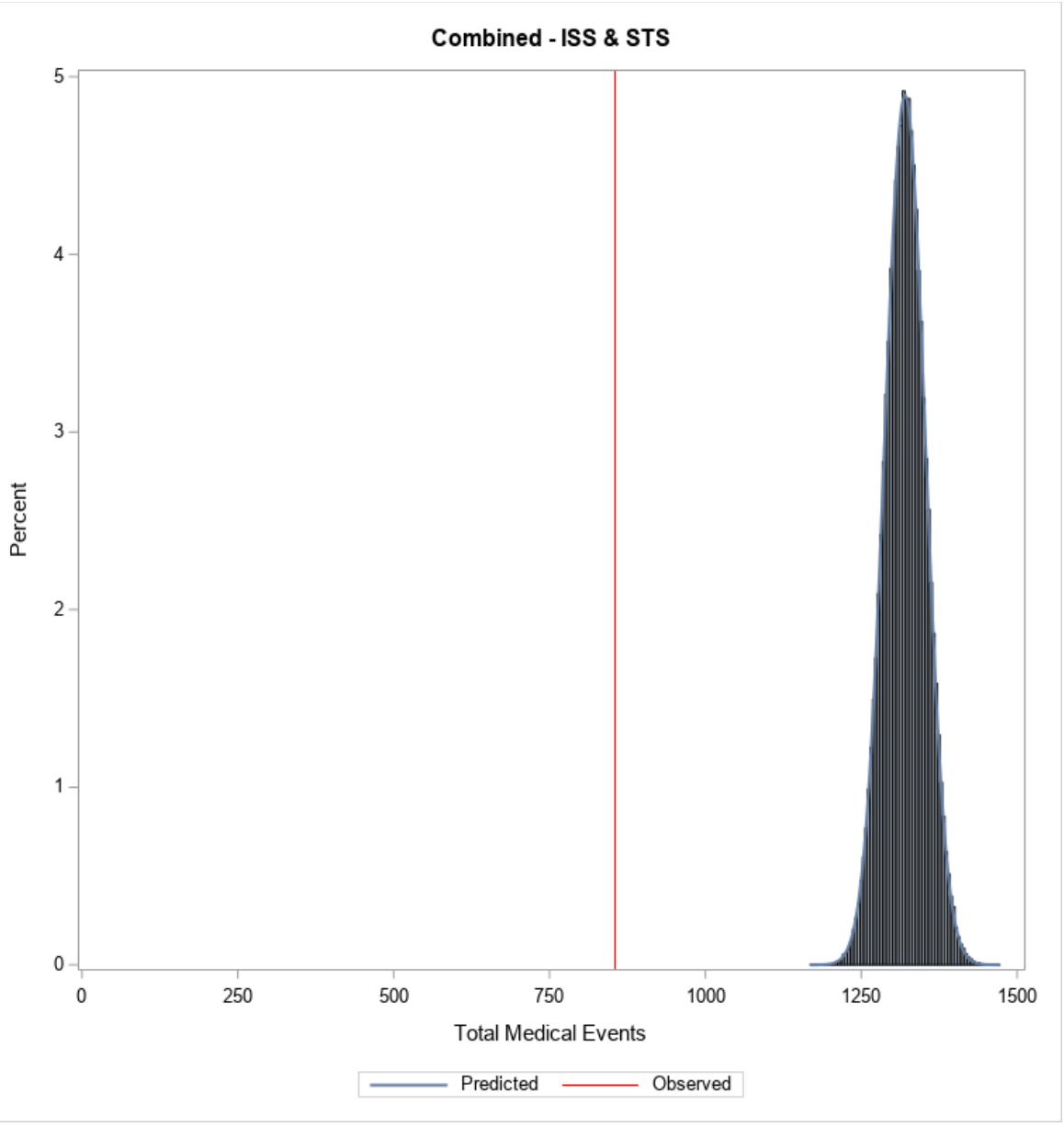
- **Typical EHR observation record data issues could lead to under-recording.**
  - Under-reporting by the crew may lead to an artificially low number of events in the real-world systems.
  - Some conditions were not recorded in earlier missions (SANS and BHP conditions).
  - Definitions of conditions changed over time and could be classified different today than when IMM did this work. Example: VIIP CPG vs SANS findings.

Results

- Results have not yet completed our clinical analysis process (scheduled for completion on 03/06/2023)
- Will include:
  - Comparison of Observed vs Expected Condition counts
  - Comparison of predicted Loss of Crew Life compared to observed of zero
  - Regression analysis by condition and by mission
    - R-square will serve as a metric of agreement
    - Slope and intercept will be evaluated. Slope should be close to 1, and intercept should be close to 0.
  - Discussion of assumptions, limitations, and any unexpected results
  - Lessons learned and suggestions for future development.

NOTIONAL (Unverified results examples)





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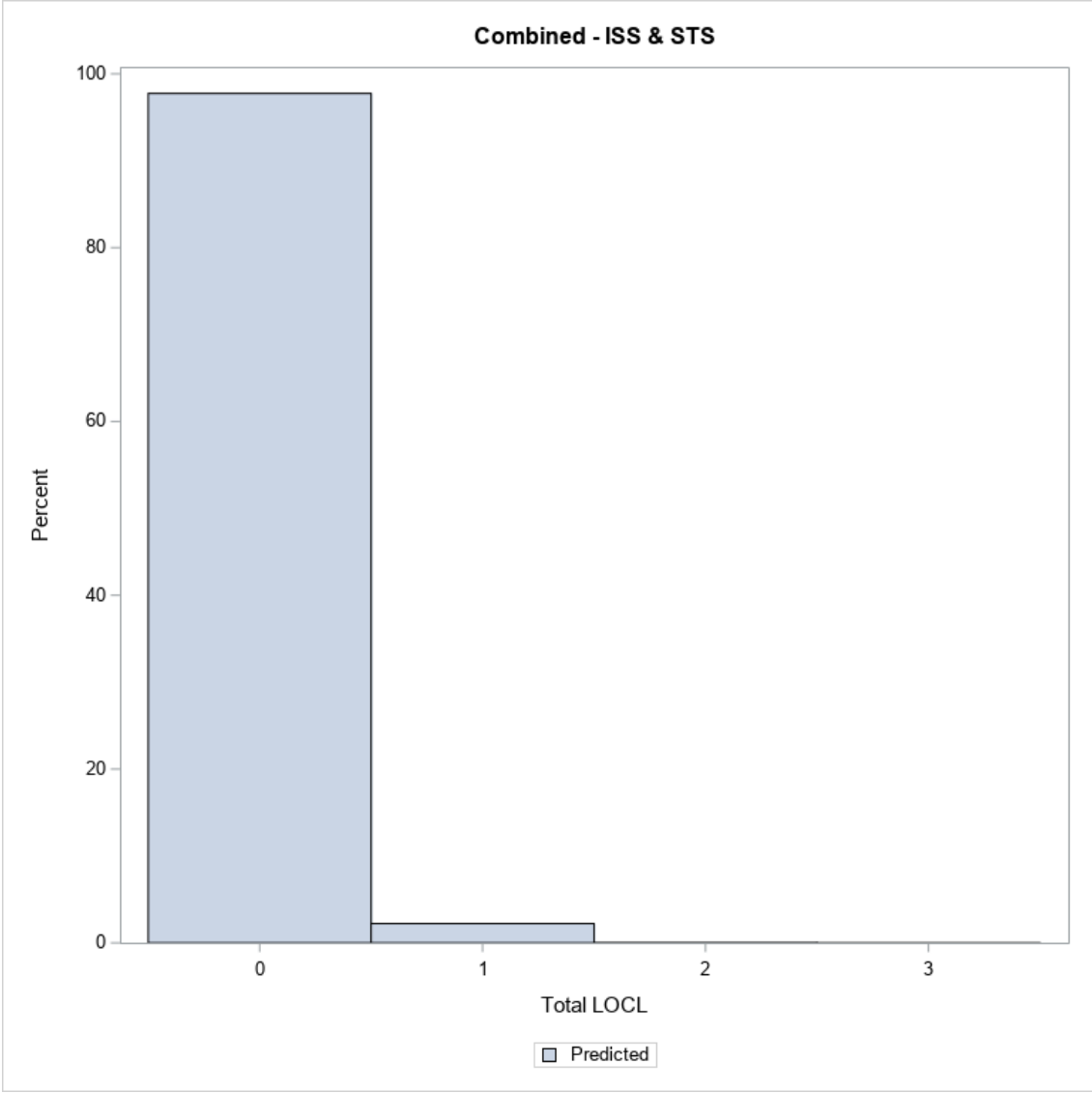
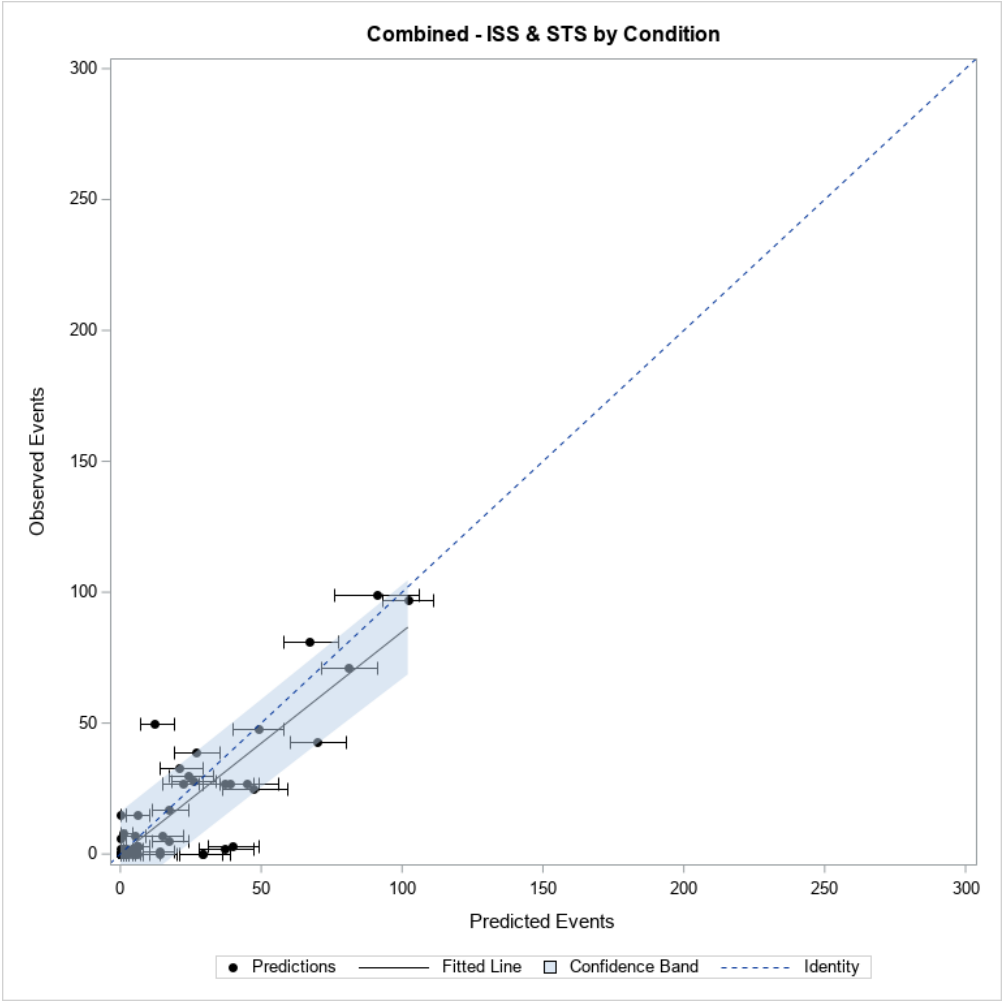


LOCL_Combined	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0	195502	97.75	195502	97.75
1	4441	2.22	199943	99.97
2	56	0.03	199999	100.00
3	1	0.00	200000	100.00

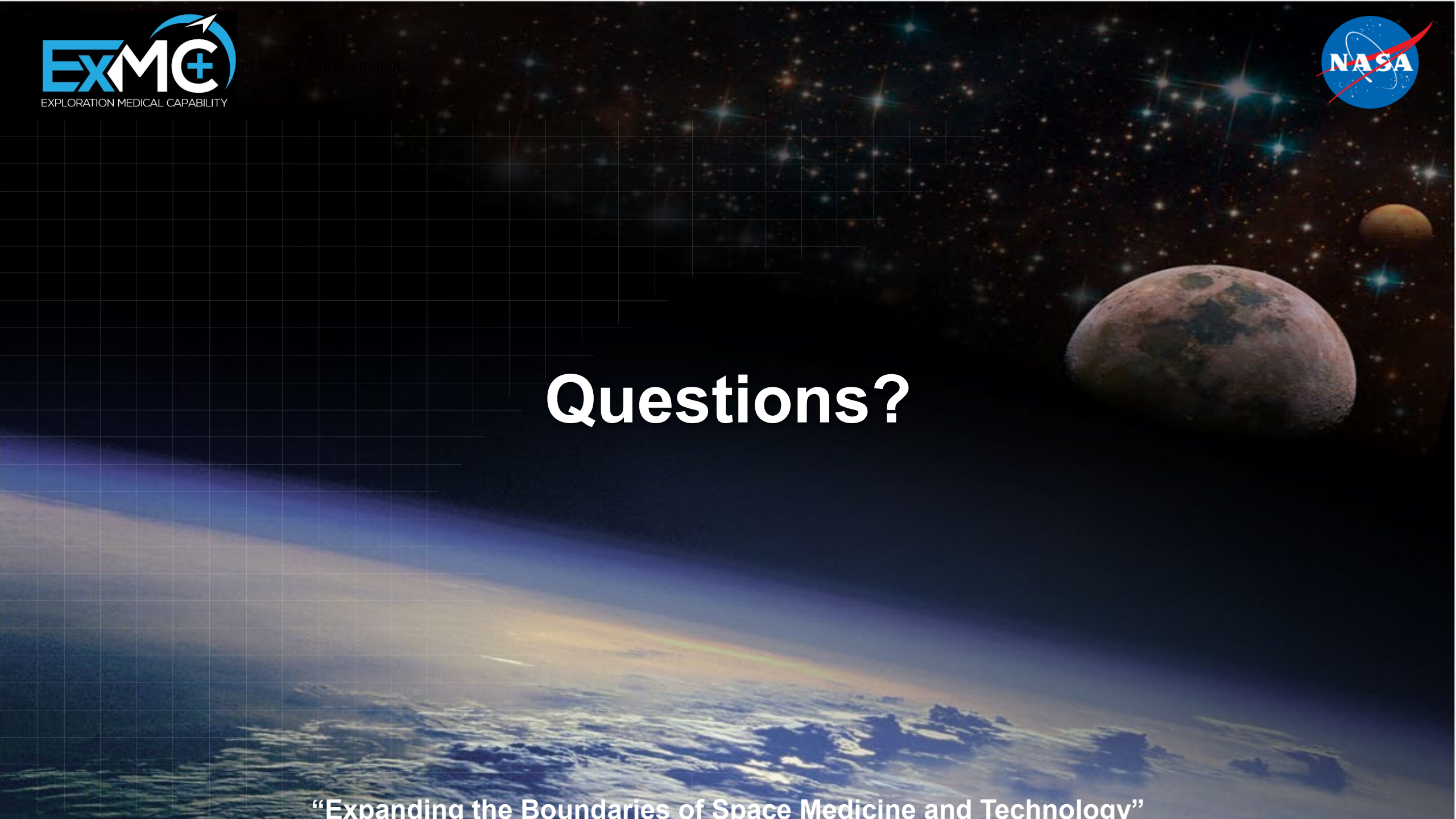
NOTIONAL (Unverified results examples)

- **Regression by Condition – Combined ISS & STS**



References

1. KBRwyle Integrated Science and Engineering Integrated Medical Model Project. (2017). *ISS Real World System Validation Report for the Integrated Medical Model 4* (IMM-GEN-303, Rev1).
2. KBRwyle Integrated Science and Engineering Integrated Medical Model Project. (2017). *STS Real World System Internal Validation Report for the Integrated Medical Model 4* (IMM-GEN-311).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